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THE CALIFORNIA PEACH-TREE BORER.

By C. W. WOODWORTH.

The Old Practice of Digging Out the Borers.

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CALIFORNIA PEACH-TREE BORER.

The most injurious insect in the Santa Clara Valley is generally conceded to be the California peach-tree borer. This insect is most abundant on peach and apricot trees, or on prune trees growing on peach and plum roots. It bores into the bark just beneath the surface of the ground, and is most easily recognized by the very characteristic masses of gum that exude from the tree at the point of attack. These borers often become so abundant as to entirely girdle large trees, causing their death; and even when not so deadly their attack seriously crippies the tree. The labor necessary to dig out or otherwise destroy these insects amounts to a great deal. This Station has been repeatedly called upon to advise in the matter of the repression of this pest, and to assist in determining the facts involved in its treatment. Experimental work undertaken in response to these inquiries has resulted in establishing some important facts, and this bulletin is designed to furnish these data and to give a general account of the history of this insect, in order that growers may more intelligently direct their operations for the suppression of the pest.

The Insect Peculiar to Santa Clara Valley.—Very diligent inquiry has failed to discover that the peach-tree borer does any serious injury in any part of the State other than the Santa Clara Valley. This is particularly remarkable from the fact that the Eastern species is so widespread and so generally injurious, and from the further fact that the region about San José has been a distributing point for nursery stock. It is from this district, most probably, that the San José scale was distributed over the State. The insect is one readily carried in nursery stock, and so we must suppose that the conditions in other parts of the State must be in some particular unfavorable to it, thus preventing its undue increase. It is difficult, however, to conceive how the conditions in this valley can be so strikingly different from those elsewhere as to make this difference in the ability of the insect to maintain itself.

Significance Elsewhere.—While at the present time the insect is thus extremely local in its distribution, there is every reason to expect that in time it may suddenly become injurious elsewhere. The moth has been collected in many localities by entomologists, and probably occurs sparingly all over the State, only awaiting the advent of the peculiar conditions which have made it successful in the struggle for existence in

the Santa Clara Valley. It is quite possible that the insect has occurred and has done injury in other regions, and that orchardists have supposed the death of the affected trees to be produced by other causes.

Relatives of this Insect in California.—The California peach-tree borer belongs to the family Sesiidæ, a small family of slender-bodied moths, mostly day-flying in their habits, and often ornamented in a manner to suggest a wasp in color and shape. The species known as occurring in this State may be distinguished by the following synopsis:

SESIIDÆ.

Tongue long, (*a*); -rudimentary. Tibiæ tufted, *Paranthene*; -hairy, *Ægeria.* —(*a*) Posterior independent vein of hind wing arising from posterior vein, (*b*); -from center of cross vein, *Melittia;* -from end of cross vein. Palpi with long hairs, *Memythrus;* -short hairs, *Albuna.* —(*b*) Tibiæ hairy, *Vespamima;* -slightly tufted. ♂ abdominal tufts narrowing, ♀ abdomen with lateral tufts, *Sanninoidea;* - ♂ fanlike, ♀ none lateral, *Sesia.*

Melittia gloriosa feeds on sumac.

Memythrus robiniæ quite injurious to poplars and locusts.

Ægeria. Abdomen except base yellow, *pacifica;* -banded, *tibialis.* These insects attack poplars and willows.

Vespamima sequoiæ attacks pines and redwoods.

Sanninoidea opalescens on peach, cherry, apricot, and prune. The most injurious species of the group and the one treated of in this bulletin.

Albuna pyramidalis.

Sesia. Abdomen all blue, *achillæ;* -all black, *albicornis;* -sides, or all of last two segments red, *animosa;* -last three or four red, *behrensii;* -fourth and last two red, *polygoni;* -all banded white, *candescens;* -all banded yellow, *novaroensis;* -two white, *prosopis;* -two yellow, *neglecta;* - ♂ with two or three, ♀ with four yellow, *rutilans;* - ♂ with four, ♀ with three, *tipuliformis;* - ♂ with six, ♀ with five yellow. Fringe red, *rileyana;* -orange, *arizoniæ.*

The food of only a few of these species has been determined. The *albicornis* preys on willows; *tipuliformis* on currants and gooseberries; *rutilans* on strawberries; and *prosopis* in the galls on mesquit.

Paranthene palmii, the food of which is unknown.

LIFE HISTORY.

A good deal yet remains to be learned in regard to the life history of this insect. No one has thus far made very careful breeding experiments, nor has there been sufficient continuous observation of field conditions, to answer all the questions that might be raised in regard to it. The life history is known to be very different from that of the Eastern peach-tree borer, as occurring in the Northeastern States. It is possible, however, that the history of that insect in the southern limit of its range might be more like that of our species, but the knowledge which we have of it in the Southern States is quite as meagre as of this species in California.

Winter Condition.—This insect is best known in its winter quarters, because it is during the winter that practically all of the work for its repression is done. In striking contrast with the Eastern borer, our insect is more or less active all through the winter season, and the

young worms grow and feed during all the warmer weather. It appears that pupation never occurs until well into the spring, even though the worm is quite large in the fall. This produces a tendency toward the production of a large spring brood of moths; but a great many of the worms that are on the tree in the winter do not transform until quite late in the summer.

The larvæ are found of all sizes during the winter. Farmers very commonly suppose that this difference in size represents distinct broods,

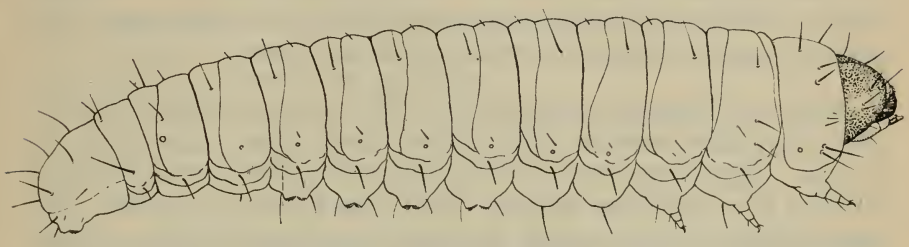

FIG. 1. A nearly full-grown larva of the Peach-tree Borer. Magnified four diameters.

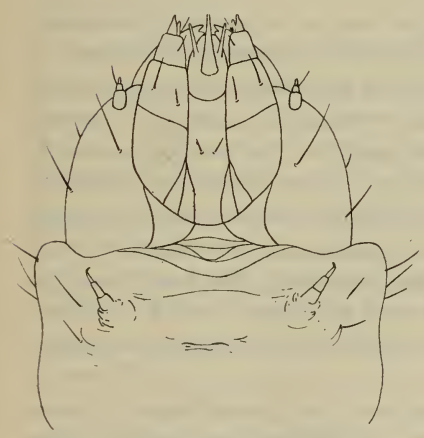

FIG. 2. The head from below. Still more enlarged.

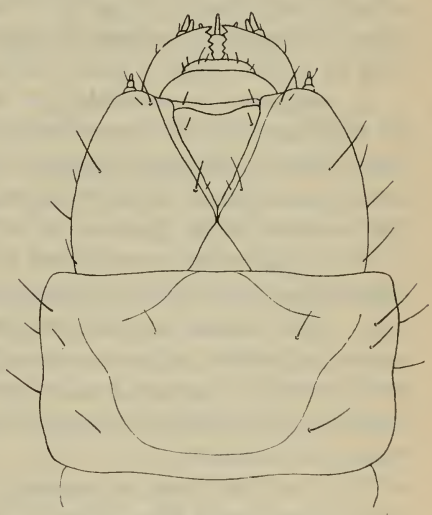

FIG. 3. The same from above.

and they commonly recognize three of these sizes, which they designate as the small, medium, and large sized worms. In fact, however, this classification is not sound, since every intergrade exists from the smallest to the largest. During the course of their development these insects molt like other larvæ, each stage possessing a very much larger head than the one immediately preceding it. The different stages can usually be quite clearly distinguished by the size of the head; but there is considerable variation in the size of two insects in the same stage, so that we have not been able to satisfy ourselves as to the exact number

of molts. This will have to be determined by careful breeding experiments. It is not likely, however, that this information will have any very significant economic bearing upon the problem of suppression. There is a great deal of difference between the burrow produced by a young worm as contrasted with that of one of the older individuals, the former being always very shallow and usually quite devoid of gumming material, whereas the burrows of the large borers extend through the bark and into the solid wood, and are almost invariably indicated by the mass of gum on the outside. The time when the burrow becomes gummy, or when the insect penetrates deeply into the bark, seems to be wholly a matter of chance, or of individual peculiarity.

The Gum.—The most evident sign that the worm is working in the bark of the tree is the exudation of a greater or less mass of gum from the burrow. This gum mass is so uniformly present that most orchardists consider it an unfailing and only sign of the work of the insect. Our observations have shown that this is far from being the case. A great many larvæ were found by careful search, especially younger larvæ, in which there was no evidence whatever of gumming; and on the other hand, conspicuous masses of gum occurred very commonly where there was no evident sign of insect work.

It appears to be probable that the gum has no necessary relationship to the insect at all, but represents rather the evidence of the work of some decay-producing organism which has gained entrance to the tree at the point where it was injured by the feeding of the borer. Indeed, the presence of the gum seems to be distasteful to the borers, sometimes it even apparently causes them to abandon a burrow and start another. Gumming also occurs not uncommonly along the edges of wounds made from other causes, and almost always accompanies the attack of toadstool fungi where it occurs along the line separating the dead from the living bark. Gumming may occur where the insect attacks the tree above the ground, but is always more copious in the moist situations below the surface.

The fact that those attempting to cut out the insect depend almost wholly upon the presence of the gum for the discovery of the burrows of the larva, results in worms being overlooked in case the gumming has not yet occurred; or sometimes the tree may be very seriously mutilated in endeavoring to find a worm corresponding to a mass of gum which has been produced by other causes.

The Burrow.—Ordinarily, there seems to be a great deal of variation in the shape and direction of the burrow—about as many burrowing up as down. The general direction of the burrow is usually more nearly vertical than horizontal, though a few may go directly around the tree. Very careful study fails to reveal any decided preference as to the side

of the tree affected, so it would seem that in all these matters the location or direction of the burrow is simply an accident.

Some have supposed that there is a certain definite arrangement that would have to be taken into consideration in the matter of treatment. The habits of the worms within the burrow are subject to no recognized rule. They appear to move about the burrow, according as the needs of feeding or cleaning-out compel them, with very little regard to temperature or time of day. The burrow appears to be always kept open by the worm, and the gum that gathers on the sides is pushed out with the excremental matter that accumulates in the burrow. Sometimes the gum hardens into a tube-like extension of the burrow, which may become as much as an inch long.

This gum tube is not to be confused with the silken tube almost devoid of gum, which is made by the insect as its transformation period approaches. The winter tube made by the Eastern species seems to resemble rather the transformation chamber than the gum tube. In many cases the transformation chamber contains more or less gum also, and indeed sometimes the tube is chiefly gum and excrement at one end, and silk and excrement at the other. Our species does not appear to have the habit of making winter tubes, but continues to feed through the cold season.

Spring Conditions.—With the commencement of the flow of the sap in the spring, the older larvæ proceed to the formation of their transformation tubes. These are sometimes, indeed quite commonly, formed within the burrows, especially if the amount of gum has not been excessive. In other cases they will be upon the surface of the bark at, or near, the mouth of the burrow. At no time of the year can a larger number of worms, preparing for transformation, be found than in the spring, due to the fact evidently that many of the wintering worms which had for a long while been full grown and were only deterred from transformation on account of the season, now suddenly find conditions favorable and proceed to prepare for their transformation. After the tube is formed and the insect ceases to feed, it still remains for some time in the larval condition, and if disturbed will wake up at once; indeed, it seems to be able to reproduce a new tube, if removed from the old one, without any particular loss to itself. Finally, however, activity ceases, the insect somewhat shrinks in size, and after a short period of complete rest, during which it is unable to walk if removed, the skin breaks and discloses the pupa which has been formed within. The life of the insect within the pupa does not last very long, exactly how long we can not state, and upon its conclusion the pupa becomes suddenly active, pushes itself out of the transformation tube and almost immediately gives forth the moth form. In Fig. 4, showing the pupa of this insect, will be seen the structures which aid them in this work of

forcing the body out of the burrow. The sharp edge appearing on the head end of the pupa, seen best in the side view, enables the insect to break the structures ahead of it, and the spines which bound the back side of most of the abdominal segments hold the insect in place, or give it a point of leverage, so that it can, by bending its body back and forth, gradually force its way forward. After it has gotten into the open, the widely spreading spines, shown at the posterior end of the body, prevent further progress and hold the pupa case to the end of the burrow during the progress of the hatching of the moth. The line of splitting

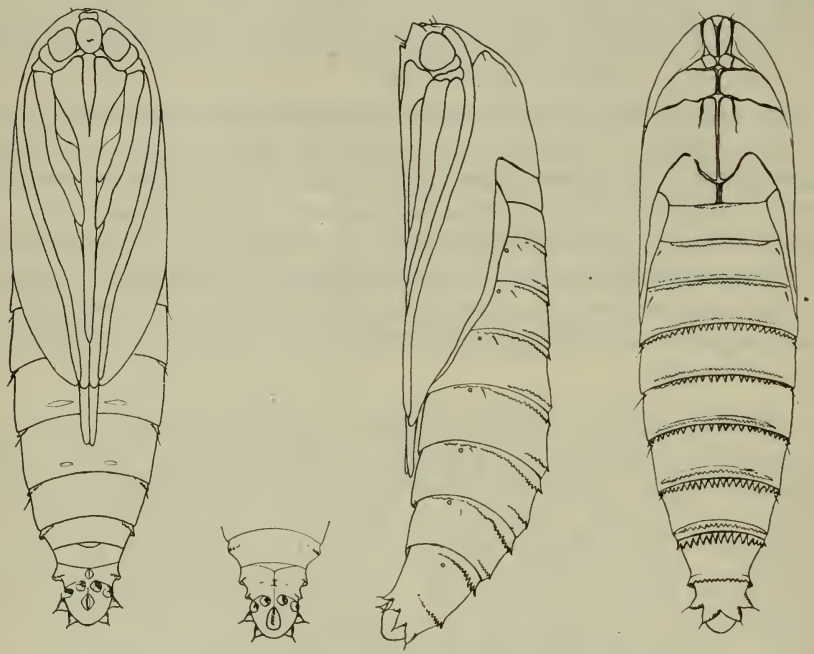

FIG. 4. Pupa of the Peach-tree Borer. Magnified about four times.

along the back, through which the moth emerges, can be seen in the right-hand figure.

The moth is not very commonly seen flying. Like the other members of the family, it flies in the daytime and not at night, as is the case with most moths. It produces a great many eggs, which are laid upon the trunks of the trees scattered about, apparently with no attempt at order. The egg is beautifully sculptured, slightly flattish, but oval in outline. The insect is quite prolific, laying some hundreds of eggs, and as they are, as a rule, laid singly, one moth can injure an immense number of trees. Young worms on hatching from these eggs enter some crack or crevice of the bark, where they lie concealed, eating into the substance of the bark, migrating about if the situation is not to their liking, and usually travel downward. As a rule, they are not satisfied until they get beneath the surface of the ground, where they find

the bark still moist. If there should be a small amount of earth in the crotch of the tree they will very often select this place, and may come to full development in the bark there. After attaining some size, usually before reaching a quarter of an inch in length, the migratory habit seems to be almost wholly lost, and the insect will thereafter ordinarily complete its existence in one burrow. Throughout its life it is active, however, in keeping its burrow clean, sometimes going quite out on the surface of the bark in case the earth is loose, and if removed from the burrow will have no trouble in establishing a new one.

Summer Conditions.—Throughout the summer there is a continuous production of moths and laying of eggs, so that at any season of the year worms can be found of nearly every size. The spring brood of moths, however, which is, as already explained, unusually numerous, results in there being a size of worm fairly uniform and more abundant in numbers than those of any other size. These worms become full grown, or nearly full grown, by autumn, but do not transform until the following spring. Those individuals that are somewhat belated may not be half grown at the time of the dropping of the leaves, but they will generally be ready for pupation by the approach of spring. Sometimes the summer moths may in some regions become more abundant than usual, so as to produce a fairly distinct lot of worms of considerably smaller size than these spring larvæ. Occasionally, also, there may be a similar abundance in the fall. These peculiarities have given rise to the idea of three broods; but it appears that while there may be three times in the year in which the moth is more abundant than in others, and three fairly distinct sizes of larvæ, still each lot requires a full year for its complete transformation. The summer and fall broods do not by any means remain distinct from the spring brood, on account of the precociousness of some individuals and the belated development of others, the latter thus becoming a part of the preceding or succeeding brood. Commonly, the summer and fall broods can not be as clearly distinguished as the spring crop of moths.

The really significant part of the outline of the life history here given is that there is no time during the summer when eggs may not be laid, and that usually the largest growth of young worms occurs early in the season, but that occasionally equally abundant layings may occur at any time in the summer. It will not be possible under our conditions, therefore, to mark out any plan of annual treatment which will be equally effective in different years.

REMEDIES.

The remedy, upon which the most dependence is placed in fighting the Eastern peach-tree borer, is that of digging out the worms. The conclusion of the very elaborate investigation by the Cornell Experiment Station was that this process must form the essential part of any plan for the control of this insect. In addition to it, the use of *tar*, *tobacco stems*, *tarred paper*, or *mounding with earth*, must be resorted to. The first of these was found to be the most effective, but possibly dangerous to the tree under some conditions.

In California all of these methods and many others have been used quite extensively and with more or less satisfactory results, but they all certainly leave much to be desired, since they do not avoid the necessity of also digging-out. The digging-out process so mutilates the tree, even

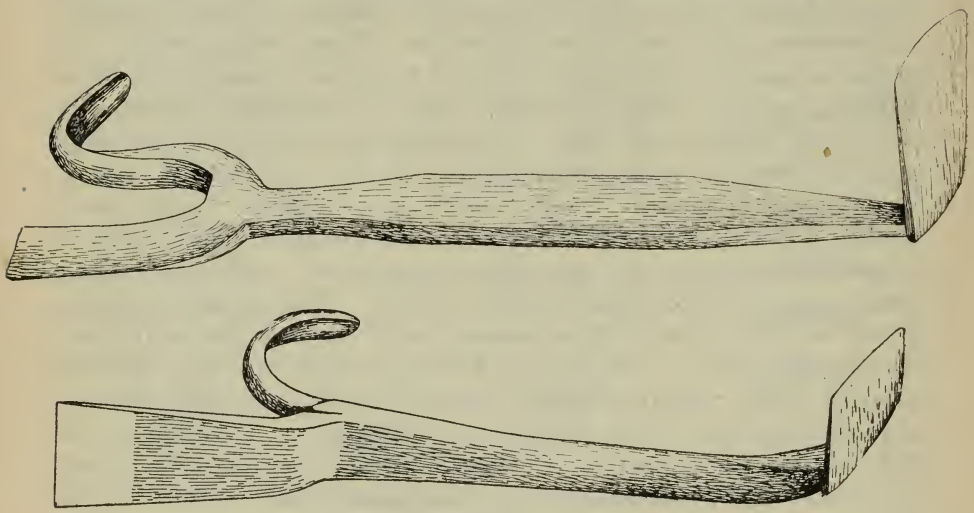

FIG. 5. Two forms of tools used in the "digging-out" method.

when the greatest care is exercised, that many growers are of the opinion that more injury is done than when the worms are left alone. When the digging is left to careless help, the tree is often very badly mutilated. Fortunately, the peach root heals over a wound very readily and is very tenacious of life, often keeping the top alive when there is but a narrow strip of bark left intact.

Digging-Out.—The tools used in digging-out are a shovel, and a pick if the ground is hard, together with a hoe or trowel for removing the earth, and a chisel, gouge, knife, or home-made tool for cutting out the insect. Several forms of these special tools are on the market in San José, two of which are here figured. Some growers prefer a blacksmith's hoof-knife instead of the form of gouge characteristic of these tools.

The time of the digging-out is almost always made a matter of convenience, and the facts we have so far learned in regard to the life history do not, as yet, prove that better results would follow a different practice. An important feature of the digging-out method is that it is extremely difficult to find all, or even the larger worms, in a tree; and if the worms are small their discovery is almost or quite impossible. A single going-over of the trees is thus only partially effective, and many orchardists have found that three times during the winter will not exhaust the supply, even though it is quite certain that no moths were flying during the intervals. The rush of other work usually prevents a summer digging-out of the worms, though it would seem that just as good or better results might follow from work at that season. We do not have sufficient data to decide accurately the relative value of the supplementary means used in connection with the digging-out process.

CARBON BISULFID.

A method that has given exceedingly satisfactory results under favorable conditions is the use of carbon bisulfid. The fact that under other conditions less thorough work was done, and that in some cases it has undoubtedly resulted in the death of the trees, does not signify that it is unavailable for the destruction of this pest. This substance has been used on a commercial scale only in California, though the suggestion was originally made for the Eastern borer by Prof. A. J. Cook, Conductor of Farmers' Institutes for southern California, then residing in Michigan. In Slingerland's experiments in New York it proved an entire failure, and was condemned by him as being too expensive, too dangerous to the tree, and entirely ineffectual against the insect. We have no record of the temperature or the condition of the soil in these experiments, and can only conjecture why the results were so unsatisfactory. Certainly, as used in the orchards about San José there is nothing as cheap as this method. When properly handled the danger to the tree is none; and in effectiveness, when conditions are right, it leaves nothing to be desired.

Danger to the Tree.—Carbon bisulfid has been used for so long a time as an insecticide for the control of phylloxera that we may be very confident as to its uniformity of action and efficiency against insects, and also of the extent of the danger to the plant.

As used against the borer the danger from this substance is wholly that of the action of the gas, since so little liquid is applied to each tree that it all evaporates before it would be possible for it to penetrate through the bark to the living tissue beneath. Some growers even make it their regular practice to pour the liquid on the bark, and without bad results. If enough material was used, or the soil was very wet so as to prevent evaporation, injury might come from the action of the liquid.

The effect of the gas is dependent upon its density and the length of time it is acting. Even the most delicate growing parts of the plant are tolerant of a weak dose of gas continued almost indefinitely. The point at which injury to root hairs occurs is very little beyond the point where it begins to be effective against insects.

With the more easily killed insects it might be possible to use the substance for the complete eradication of a subterranean insect, if we could obtain an even distribution of the gas in the soil.

In actual practice it is found that in the case of phylloxera the use of a strength that will be safe to the plant, almost always leaves somewhere a little colony of these creatures which are able in a short time to repopulate the vine and require another treatment. This repetition, every season or two, is very expensive in field work, so that it pays only in unusually valuable vineyards. The chief uses of this chemical have become, therefore: first, the stronger "death treatment," with which both vines and insects are destroyed together; and, second, for disinfecting cuttings or vines removed from the soil. In the latter case they are given a still stronger dose, but for a shorter period, and even though the smaller rootlets may be killed, the plant does not die, because being planted in new soil it can replace any dead parts at once. The bark-covered parts of the plant are many times more resistant to carbon bisulfid vapor than are the growing rootlets and root hairs, and these latter are quite as resistant as most insects.

In treating a peach tree, should there be any root hairs immediately about the crown they might be killed by the carbon bisulfid at the strength used, but this would not amount to anything to the tree. The danger to the tree would only come from a strength of gas and a length of time of treatment sufficient to injure the most resistant part of the root-system.

The amount used in any case should not be sufficient to cause the death even of root hairs very far away from the trunk; and the real danger to the tree is not from too great destruction of root hairs, but from the danger that the gas be retained about the crown in a concentrated condition long enough to cause the death of the more resistant parts of the tree.

The only thing that could cause this retention of the gas about the crown is the presence of water in the soil, which closes up the spaces between the soil particles, through which the gas gradually diffuses itself. The danger is greatest in heavy soils. In a very light, sandy or gravelly soil the difficulty would more likely be that the soil might be so dry that the gas would diffuse so rapidly as to fail to kill the insect; in that case, of course, being also perfectly harmless to every part of the tree. Practice has shown that there is a wide margin between effectiveness against the insect and danger to the bark of the

tree. Intelligently applied, there is no reason why it might not always be entirely safe and effective.

Condition of the Soil.—The character and condition of the soil is the most important consideration in the use of carbon bisulfid. The same soil varies most greatly near the surface in the amount of moisture it contains, and unlike the phylloxera work, it is here in this variable surface soil that this treatment is to be made.

Extreme conditions should certainly be avoided, and uniform results require uniform conditions. The best results have usually been obtained in the orchards where the soil was rather light and in the best condition of tilth. Under these circumstances, the method of procedure is the simplest. All that is necessary is to pour the carbon bisulfid upon the ground around the tree close to the trunk and immediately mound up the earth a few inches against the base of the tree. In most soils it will be necessary, in order to secure the best results, to remove the soil that immediately surrounds the tree, as this is somewhat hard and packed, and to replace it with loose soil taken from the surface stirred by the culti-

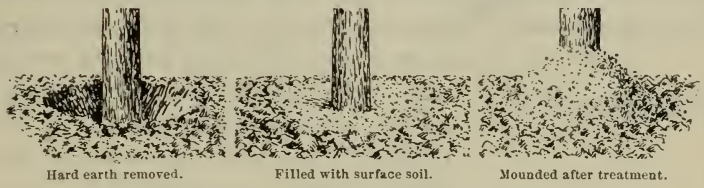

FIG. 6. Method of treatment in medium and heavy soils.

vator. This is made level and the carbon bisulfid applied as before, and more loose soil used in mounding. If the soil is rather wet or heavy it will be necessary to remove this soil impregnated with the chemical, so as to give the gas an opportunity to dissipate itself after a day or two, and thus prevent too long an exposure of the root crown to the gas.

Except on the lightest soils the earth should always be removed if a rain should intervene, as it will effectually seal up the gas and prevent its escape into the air.

In some orchards sufficiently dry soil may not be found for filling the excavations at the time it is desired to make the treatment, in which case chaff or straw may be used instead, covering it well with earth after pouring on the carbon bisulfid. This should, of course, also be removed after a day or two.

In very dry, light soils, if the carbon bisulfid dissipates itself too rapidly to accomplish the desired destruction of the borer, the use of water will make it effective. For this purpose, excavate around the trunk, then wet the soil, put back the earth, making all level, apply the carbon bisulfid, bank up the earth, and sprinkle the top slightly. In a day or two the extra earth may be removed, if it has not dried out enough to permit the escape of the gas.

The Dose.—In the matter of the quantity to be applied to a tree, there is a great deal of difference in the practice of different orchardists. Economy would favor as small a dose as will be sufficient, but if too small, nothing will be accomplished by the treatment, so orchardists generally feel that it is better to give too much than too little. It will not be possible to recommend a dose that will do for all conditions. Probably a larger number try to make their average dose about one ounce than any other amount; and this may be taken as a tentative dose to experiment with. Each orchardist must determine for himself that which will be best under his conditions. The most important factor in this matter is the degree of looseness of the soil. The heavy, compact, moist soils require the smallest dose; and the lighter, looser, and drier soils a larger quantity of the carbon bisulfid.

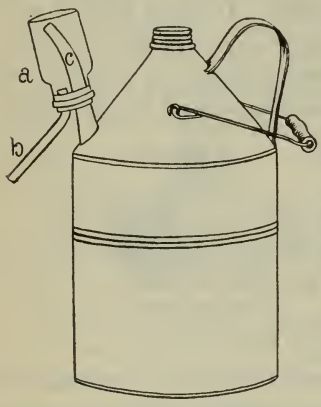

FIG. 7. Can for measuring dose of carbon bisulfid.

The common practice is to vary the dose according to the size of the tree, putting often several times as much around a large tree as a small one. Some little variation of this kind should occur, but not as much as is the practice. In an orchard with fairly uniform trees the best practice would be to make the dose uniform, without regard to the small variation in the size of the tree. A little change in the character of the soil in different parts of the orchard is a very much more significant matter.

The method of applying carbon bisulfid usually adopted is the use of a common machine oil-can. This has the advantage of convenience, but makes it difficult to apply a uniform dose. The deposition of sulfur in the spout decreases the rate of flow, and often gives trouble and makes the judging of the size of the amount discharged very difficult. We have planned a can by which a uniform dose can be rapidly measured and applied. It is shown in Fig. 6. It consists of an ordinary kerosene can, or a machine oiler could be used instead. A bottle (*a*) with a doubly perforated cork and discharge tube (*b*) is attached to the spout (*c*). The can is reversed until the bottle-measure is filled, when by righting it the liquid will pour out of the discharge tube. A bottle of any required size, fitted with perforated cork, can be had at any drug store.

Summer Treatment.—So far the use of the carbon bisulfid, like the digging-out process, has been almost wholly confined to the winter season. This has been chiefly because this season is the least busy, and partly because of the fear that there would be more danger to the tree if the chemical were applied when the tree was not dormant.

The danger to the tree at this season is not at all greater than when the tree is dormant, when the treatment is made in the manner employed for this insect. The drier average condition of the soil, which favors the rapid diffusion of the gas, may cause some trouble, on account of the difficulty of keeping the dose strong long enough to kill the insect.

Quite as much, or more, of the injury to the trees is done by the worms during the summer than during the winter, and it would seem desirable to make one or more applications to prevent this summer injury. As so many of the worms are small in summer, digging-out would be very difficult to do in a thorough manner; but carbon bisulfid finds no more difficulty in discovering a small worm than a large one, and the injury is stopped before it is hardly begun.

If but a single application is to be made, the best time to do it is early in the winter, after all the eggs have hatched and no more moths are flying. The earlier worms will have already done considerable injury by this time, which might be prevented by a midsummer treatment. Whether more treatments than these two will be profitable in most seasons it is not possible now to say, but careful observation of the condition of the trees in an orchard ought to enable any grower to come to satisfactory conclusions on this subject.

SUMMARY.

While the peach-tree borer is at present injurious only in the Santa Clara Valley, a watch should be kept for it elsewhere.

As far as known we have but one brood a year, but worms in all conditions can be found at almost any season, and moths fly and lay eggs all summer.

The presence of the gum can not be depended upon as an indication of the young worm, so that it is difficult to get all when digging them out.

Carbon bisulfid has proven a most efficient method of killing the worms.

The use of carbon bisulfid is not without danger to the tree, but with proper caution is safe.

The condition of the soil is the most important item to consider in the use of carbon bisulfid.

The soil next to the tree must be loose enough to allow the gas to reach every part of the crown, in order to kill all the worms.

Uniform treatment as to dose should be attended to. The time for the most important treatment is in the early winter. Probably, in addition, a midsummer treatment would be nearly as useful.